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Growth, Productivity Behavior and Economics of Castor (*Ricinus communis* L.) Hybrids as Influenced by Different Fertility Levels under North Gujarat Agroclimatic Region

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Abstract: A field experiment was conducted at Castor-Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar during kharif season of 2016-17 with five castor hybrids (DCH 1720, SHB 896, DCH 177, DCH 519 and GCH 7) grown with three fertility levels (50% RDF, 100% RDF and 150% RDF). Results revealed that among the castor hybrids studied, SHB 896 registered significantly higher number of effective branches plant^{-1}, 100-seed weight, seed yield, oil content, net return, BCR, crop productivity and crop profitability of castor. On other hand, application of 150% RDF gave significantly higher yield attributes, yield and monetary returns i.e. number of branches plant^{-1}, seed yield, oil content, net return, BCR, crop productivity and profitability of castor compared to other fertility levels under Northern Gujarat conditions.

Key words: Castor, fertility levels, hybrids, productivity, profitability, yield.

Castor is an important non-edible oil seed crop of the arid and semi-arid regions having high industrial importance due to the presence of unique fatty acid and ricinoleic acid. Castor is extensively cultivated in India, Brazil, China, Ethiopia and Thailand. At present, India is the world leader in castor production and sole exporter of castor oil, seed and its derivatives. Currently, the total castor production is 11.96 lakh tons obtained from 7.51 lakh ha with a productivity of 1593 kg ha^{-1} in India (Anonymous, 2019). Gujarat is the largest castor growing state of India. Here it is grown over an area of 5.21 lakh ha with the annual production of 9.44 lakh ton with an average productivity of about 1809 kg ha^{-1}. It shares about 69.5% of the total area and 78.9% of the total castor production of the country (Anonymous, 2019). Castor is one of the most important crop of north Gujarat under irrigated as well as rainfed region which is widely adaptive under varying environmental condition. The productivity of castor is low due to poor crop management practices and low resource allocation coupled with lack of high yielding improved hybrids adaptive under diverse environmental condition. Both low and excess application of fertilizers hinders crop performance and pollutes the soil environment. Hence, balance nutrient supply is a key factor for realizing high yield and profits with sustaining environment. However, response of different cultivars may differ with different fertility levels in a particular region. So, it becomes imperative to find out the performance of hybrids under various levels of fertilizer dose and also assess their economic feasibility. Therefore, present investigation was conducted to find out the appropriate fertilizers level for different castor genotypes under North Gujarat Agroclimatic region.

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Materials and Methods

A field experiment was conducted at Castor-Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar, Gujarat during kharif season of 2016-17. The soil of the experimental field was loamy sand in texture, medium in organic carbon (0.30%), pH (7.4), low in available nitrogen (143.0 kg ha^{-1}), medium in available phosphorus (42 kg ha^{-1}) and medium in available potassium (211 kg ha^{-1}). The experimental site has semi-arid and sub-tropical climate with hot dry summer and cold winter. A total rainfall of 585 mm received in 31 rainy days was recorded with maximum distribution in July and August in 2016. The weekly mean maximum temperature varied from 28.4 to 43.0°C (average 33.5°C) along with minimum temperature that ranged from 9.6 to 28.0°C (average 21.2°C), respectively (Fig. 1). The experiment comprised of 15 treatment combinations with five castor hybrids i.e. DCH 1720, SHB 896, DCH 177, DCH 519 and GCH 7

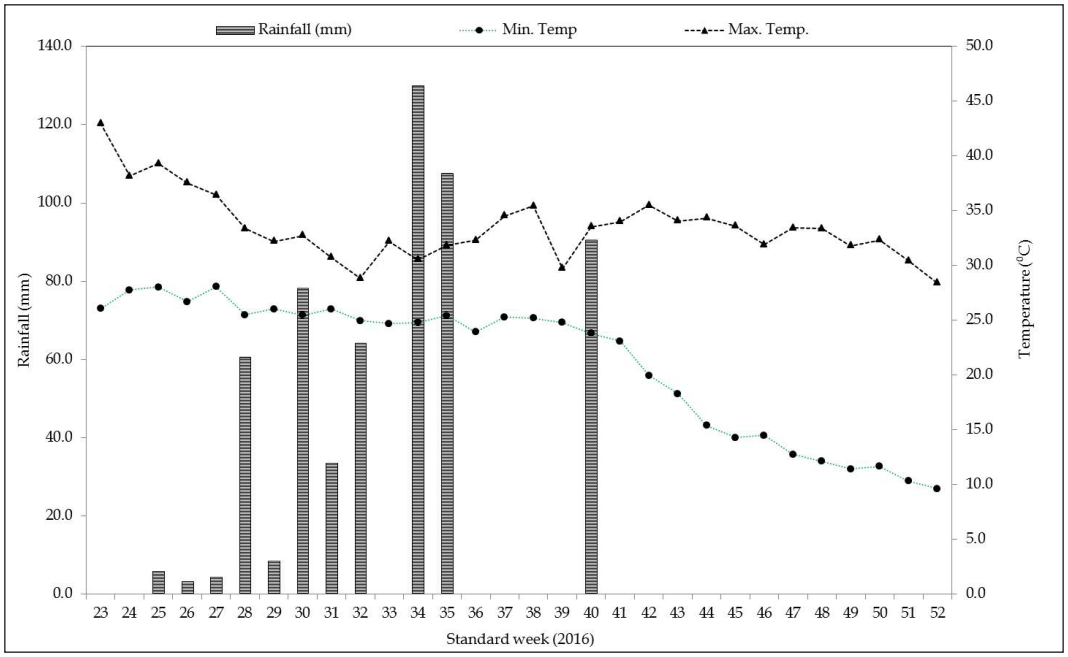

Fig. 1. Weekly rainfall and temperature during kharif season 2016.

and three fertility levels i.e. 50% recommended dose of fertilizer (RDF), 100% RDF and 150% RDF. The experiment was laid out in factorial randomized block design with three replications. Castor hybrids were sown on 14 August, 2016 in rows 120 cm apart with plant to plant distance of 60 cm. Recommended dose of fertilizer (RDF) i.e. 180-37.5-00-20 kg N-P-K-S ha^{-1} for castor. Full dose of phosphorus, sulphur and 1/4th part of nitrogen were made as per treatments to earmarked plots as basal. Remaining 3/4th dose of nitrogen were applied in 3 equal instalments at 30-35, 60-65 and 90-95 DAS. Nitrogen, phosphorus and sulphur were supplied through urea, diammonium phosphate and elemental sulphur, respectively. The weed management operations were done twice by manually as well as interculturing by tractor operated cultivator. Six irrigations were applied during cropping period. Other management practices were adopted as per package of the crop under irrigation situation. All four pickings were completed up to March last week.

Production efficiency was calculated by using the formula:

$$\text{Production efficiency (kg ha}^{-1}\text{ day}^{-1}\text{)} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Crop duration (days)}}$$

Economics like cost of cultivation and net return were worked out by considering prevailing local market prices of inputs during the period of investigation. Net return was estimated by subtracting total cost of cultivation from gross return. Benefit: cost ratio (BCR) was worked out through dividing gross return by total cost of cultivation. Return per day of castor was calculated by using the following formula:

$$\text{Return per day (Rs. ha}^{-1}\text{ day}^{-1}\text{)} = \frac{\text{Net return (Rs ha}^{-1}\text{)}}{\text{Crop duration (days)}}$$

Partial factor productivity (PFP) was calculated for different nutrients viz. N, P and S in terms of seed yield production per unit application of that particular nutrient as:

$$\text{Partial factor productivity of N or P or S (kg seed yield kg}^{-1}\text{ nutrient applied)} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{N or P or S applied (kg ha}^{-1}\text{)}}$$

All the observed data were statistically analysed as per the procedure of analysis of variance and significance of a factorial randomized block design was tested by "F" test (Gomez and Gomez, 1984). Standard error of means (SEm±) and least significant difference (LSD) at 5% level of significance were worked out for mean values of each parameter to draw a valid conclusion and logical inference.

Table 1. Effect of fertility levels on growth and yield characters of castor hybrids

Treatments	Plant height (cm)	No. of nodes plant^{-1}	No. of effective branches plant^{-1}	Length of primary spike (cm)	No. of capsules on main spike	100 seed weight (g)	Seed yield (kg ha^{-1})
Castor hybrids							
DCH-1720	123.30	17.70	13.50	58.78	76.60	30.54	4472.0
SHB-896	82.50	15.30	21.90	62.20	50.00	32.35	4859.0
DCH-177	65.50	13.80	18.20	45.87	34.30	30.64	3926.0
DCH-519	95.40	15.90	14.70	64.02	67.00	27.87	4284.0
GCH-7	91.00	18.10	21.10	58.16	52.00	31.10	4324.0
SEm±	3.85	0.29	0.60	1.81	1.80	0.58	106.6
CD (P=0.05)	11.16	0.84	1.75	5.25	5.20	1.68	308.7
Fertility levels							
50%RDF	92.10	16.60	16.20	56.80	54.40	29.91	3742.0
100% RDF	90.40	16.00	18.10	56.90	56.30	30.21	4335.0
150% RDF	92.10	15.80	19.30	59.70	57.20	31.38	5042.0
SEm±	2.99	0.23	0.47	1.40	1.40	0.45	82.5
CD (P=0.05)	NS	NS	1.35	NS	NS	NS	239.1

Results and Discussion

Hybrids

Amongst all hybrids, DCH 1720 registered significantly higher plant height (123.3 cm) and number of capsule on primary spike (76.6) as compared to remaining hybrids (Table 1). However, in case of number of effective branches plant^{-1} and 100 seed weight (32.35 g) hybrid SHB 896 had maximum value (21.9 and 32.35 g) which was significantly higher over rest of genotypes. While, number of nodes plant^{-1} and length of primary spike was recorded significantly higher by the hybrids GCH 7 and DCH 519, respectively. Variation in genetic constituent of different genotypes may be the reason for their differential growth behaviours. These results are in accordance with the earlier findings of Severino *et al*., 2012 and Anjani, 2014. SHB 896 produced significantly higher seed yield (4859 kg ha^{-1}), oil content (50.7%) and oil yield (2461 kg ha^{-1}) over rest of the genotypes (Table 1 and 2). The increased seed yield of SHB 896 could mainly be attributed to comparatively higher number of effective branches plant^{-1} and 100 seed weight of this hybrid. Several workers have also reported the variation among the genotypes of castor yield and growth characteristics (Senthil Kumar and Venkatachalam, 2017).

Highest net return (Rs. 182504 ha^{-1}), BCR (6.04), crop productivity (21.6 kg ha^{-1} day^{-1}) and profitability (Rs. 811 ha^{-1} day^{-1}) of castor was recorded by genotype SHB 896, which was significantly superior over rest of the hybrids (Table 2). The economic benefits accrued could be attributed to better growth and yield of this hybrid under optimum fertility level. Similar conclusions were also drawn by Chongtham *et al*., 2018 in single cut sorghums. Partial factor productivity of nitrogen was not influenced significantly due to different castor hybrids but it was marginally higher with SHB 896 (37.4 kg seed yield kg^{-1} nitrogen applied). While, partial factor productivity of phosphorus and sulphur was significantly higher under SHB 896 with the margin of 10.81 and 10.79, 13.88 and 13.85, 14.75 and 14.72, & 25.78 and 25.72% higher over DCH 1720, DCH 519, GCH 7 and DCH 177, respectively (Table 2). Similar results have also been reported by Ramanjaneyulu *et al*., 2013 in castor in South India and Kalhapure *et al*., 2020 in wheat.

Fertility levels

Growth and yield characters such as plant height, number of nodes plant^{-1}, length of primary spike, number of capsule on primary spike, 100 seed weight was numerically higher under 150% RDF even though the differences with other fertility levels were statistically at par (Table 1). However, higher number of effective branches plant^{-1} (19.3) was registered under 150% RDF. Similarly, higher oil content, oil yield and seed yield was registered under

Table 2. Effect of fertility levels on quality, productivity, economics, profitability and partial factor productivity of castor hybrids

Treatments	Oil content (%)	Oil yield (kg ha^{-1})	Crop productivity (kg ha^{-1} day^{-1})	Net returns (Rs. ha^{-1})	B:C ratio	Crop profitability (Rs. ha^{-1} day^{-1})	Partial factor productivity (kg seed yield kg^{-1} nutrient applied)		
							Nitrogen	Phosphorus	Sulphur
Castor hybrids									
DCH-1720	47.60	2137.00	19.90	165086.0	5.54	734.0	34.10	136.90	256.70
SHB-896	50.70	2461.00	21.60	182504.0	6.04	811.0	37.40	151.70	284.40
DCH-177	46.60	1830.0	17.40	140531.0	4.87	625.0	29.90	120.60	226.20
DCH-519	48.00	2053.00	19.00	156638.0	5.32	696.0	32.90	133.20	249.80
GCH-7	48.30	2096.00	19.20	158443.0	5.36	704.0	32.80	132.20	247.90
SEm±	0.30	53.68	0.47	4795.7	0.13	21.3	2.27	3.57	6.69
CD (*P*=0.05)	0.87	155.50	1.37	13892.5	0.38	61.7	NS	10.34	19.38
Fertility levels									
50%RDF	47.70	1790.00	16.60	134633.0	4.99	598.0	41.60	199.60	374.20
100% RDF	48.30	2097.00	19.30	158920.0	5.40	706.0	40.00	115.60	216.70
150% RDF	48.70	2460.00	22.40	188368.0	5.89	837.0	18.70	89.60	168.10
SEm±	0.23	41.58	0.37	3714.7	0.10	16.5	1.76	2.76	5.18
CD (*P*=0.05)	0.67	120.45	1.06	10761.1	0.30	47.8	5.10	8.01	15.01

150% RDF (5042 kg ha^{-1}) which was significantly superior over lower levels of fertility. Sufficient supply of nutrients might have enhanced growth promoting substances, which led to accelerated cell division and elongation, and ultimately resulted in luxuriant vegetative and reproductive growth in terms of plant height, nodes plant^{-1}, number of branches plant^{-1}, capsules spike^{-1} and length of spike (Rana *et al*., 2006).

Crop productivity improved statistically with increasing levels of fertility up to 150% RDF (23.3 kg ha^{-1} day^{-1}). In case of profitability, highest value was recorded in 150% RDF (Rs. 872 ha^{-1} day^{-1}). Application of 150% RDF also registered significantly higher net return (Rs. 188368 ha^{-1}), BCR (5.89). This could be attributed to better growth and yield under high fertility level (Table 2). These results are in agreement with the finding of Chongtham *et al*., 2018. Partial factor productivity of nitrogen, phosphorus and sulphur decreased with increasing levels of fertility. Higher partial factor productivity of nitrogen (41.6), phosphorus (199.6) and sulphur (374.2) was recorded with application of 50% RDF (Table 2). Kalhapure *et al*., 2020 also reported this kind of results in wheat.

Based on above findings, it may be concluded that castor hybrid SHB 896 fertilized by 150% RDF should be advocated for maximize yield, productivity and profitability under Northern Gujarat Agroclimatic region.

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